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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue
Seattle, WA 98101

SEP 28 1999

Reply To
Attn Of: OAQ-107

Mr. Tom Chapple
Alaska Department of Environmental Conservation
410 Willoughby Avenue, Suite 105
Juneau, Alaska 99801-1795

Re: EPA Review of Cominco Alaska Proposed PSD Permit

Dear Mr. Chapple:

I am sending you this letter as a followup to Chuck Findley's recent discussion with Michelle Brown regarding EPA's concerns with ADEC's proposed prevention of significant deterioration (PSD) Permit Number 9932-AC005 for the Cominco Alaska, Inc. (Cominco) Red Dog Mine facility. As promised, enclosed is the EPA staff review of ADEC's Technical Analysis Report.

Based on the conversation between Ms. Brown and Mr. Findley, I understand that ADEC will not start the 5-day consistency review process on the Cominco PSD permit until after, at the earliest, EPA has the opportunity to discuss the enclosed report with ADEC. Again, EPA urges ADEC to delay issuance of the PSD permit to Cominco until the permit complies with the Clean Air Act and is consistent with the issues raised in this staff review report and in EPA's prior communications with ADEC.

Doug Hardesty, of my staff, will call you on Wednesday to arrange a discussion of the issues raised in the enclosed review. If you have any questions, please feel free to contact Doug at (206) 553-6641.

Sincerely,

for Anita Frankel, Director
Office of Air Quality

CC: J. Stone, ADEC

Enclosure

COM 50-001

Review of Technical Analysis Report and PSD Permit for the Production Rate increase at Cominco Alaska, Incorporated's - Red Dog Mine

Region 10 of the Environmental Protection Agency has reviewed the final technical analysis report (TAR) for the draft air quality control construction permit (No. 9932-AAC005) to allow the implementation of the Production Rate Increase project at Cominco Alaska, Inc.'s, lead and zinc mine. The Region asserts that the Alaska Department of Environmental Conservation (ADEC) analysis of the project was inadequate in four main areas resulting in erroneous findings.

(1) The permit does not require installation and operation of the best available control technology for oxides of nitrogen on the 5 MW Wartsila engines (MG-5 and MG-17) used by the facility to produce electricity.

(2) Permit modifications to the NOx emission for units MG-1, MG-3 and MG-4 result in potential emission increases from each of the units without requiring BACT.

(3) Due to modeling analysis deficiencies, the ambient impact assessment indicates that the PM-10 increment (particulate matter with a mean aerodynamic diameter less than 10 microns) may be violated on the existing haul road; and

(4) The permit fails to adequately address other ambient air concerns including establishing a lawful and clear boundary delineating ambient air.

The Region concludes that the PSD permit should not be issued until the project meets the requirements of the Clean Air Act and addresses the concerns listed below.

Best Available Control Technology

Alaska regulations in 18AAC 50.310 (d) requires "a demonstration that the proposed limitation represents the best available control technology for each air contaminant and for each new or modified source." Therefore, the Best Available Control Technology (BACT) is required to be installed on each modification which undergoes a significant net emission increase.

BACT is conducted on a case-by-case basis using the top-down approach by ranking all control technologies in descending order of control effectiveness, then eliminating the technically infeasible options. After identifying and listing the available control options, the next step is to determine the energy, environmental and economic impacts of each option. The EPA has concerns primarily with the BACT analysis for the Wartsila engines.

Top-down Analysis

The ADEC did a commendable analysis in determining that selective catalytic reduction (SCR) for the internal combustion Wartsila units is technologically feasible and available. The ADEC states that a carefully designed SCR system can achieve NOx reduction efficiencies as high as 90% with an ammonia slip vendor guarantee of no greater than 10 parts per million (ppm). Region 10 has additional data which support these findings. For example, Wartsila has supplied the EPA with a list of 33 facilities which have installed SCR on more than 50 of their engines worldwide totaling approximately 470 MW of power generation. Installations include numerous facilities in cold climates such as Sweden and Norway as well as remote locations. Domestic installations of SCR on diesel-fired engines include Kauai Electric, Yale University and the Philadelphia Water Department. Conversations with catalyst vendors indicate that this technology has been available since the early 1990's. The DEC also indicated on page 34 of the TAR that no clear evidence has been found that the technology would be problematic in Alaska.

Furthermore, according to EPA's Alternative Control Techniques (ACT) document (EPA-453/R-93-032) for control of "NO_x Emissions from Stationary Reciprocating Internal Combustion Engines," July 1993, several more such installations exist:

> "One base-metal catalyst vendor's diesel-fired SCR experience is presented in Table 5-11 and shows six U.S. installations with a total nine engines....The available data show diesel-fired SCR applications using either zeolite or base-metal catalysts achieve NO_x reduction efficiencies of 90+ percent, with ammonia slip levels of 5 to 30 ppmv. These installations include both constant- and variable-load applications." (Attached)

EPA agrees with ADEC's analysis that SCR is technically feasible at Cominco.

Environmental Impacts

Cominco maintained that the storage, use and emission of ammonia would result in unsafe conditions for the workers and adversely impact the environment. ADEC refuted these arguments. ADEC found no basis that ammonia emissions would affect the health-based standards or vegetative impacts. In addition, the accidental release and use of ammonia in catalytic control posed a small risk to workers and visitors. ADEC concluded that they believe ammonia use is safe and routine with proper controls, as demonstrated by an excellent safety record on similar units and turbines. Furthermore, ADEC concluded that NOx emissions reductions resulting from operation of the selective catalytic reduction system would improve workplace conditions. Based on the research of information conducted by ADEC, the state could not find any probable adverse environmental impacts at the Red Dog mine using an ammonia-based or urea-based catalytic control.

Energy Impacts

Cominco raised the issue that installation of SCR on MG-5 would result in having to remove a heat recovery unit from the stack and install either heat recovery on an existing unit which does not currently have such a device or an entirely separate stand alone boiler for heat generation. These energy concerns were included by ADEC in calculating the cost effectiveness for SCR by accounting for the additional costs of removing the heat recovery from MG-5 and installing it elsewhere.

Economic Impacts

Cost-effectiveness is one of the economic impact analyses which may be considered when determining if a technology represents BACT for a specific application. However, a poor cost effectiveness in and of itself should not be construed as a measure of adverse economic impacts. Cost-effectiveness is generally described as dollars per ton of pollutants reduced. Average cost-effectiveness is determined by calculating the total annualized costs of control divided by annual emission reductions (the difference between the baseline emission rate and the controlled emission rate). To that end, the Region contends that an accurate cost-effectiveness for the SCR option is well within the range of reasonable costs for controlling NOx from the Wartsila engines. Early in the process, the Region informed ADEC that a reasonable cost-effectiveness of controlling NOx emissions from similar sources would be no greater than $10,000 per ton of NOx removed. The capital cost to install SCR on MG-5 and MG-17 was estimated to be $3.6 and $2.9 million, respectively with an annual operating cost of $760,000 and $635,000, respectively. The above noted costs result in a cost effectiveness of approximately $2,360 per ton of NOx removed for MG-5 and $2,100 for MG-17. Although the Region has reason to believe that those cost estimates are higher than would be expected, this analysis will rely on those estimates.

The reasoning behind the higher costs for MG-5 included costs associated with heat recovery. On page B.30 of the New Source Review Workshop Manual, the guidance states that only direct energy costs associated with the use of the control device (to run the device) should be considered in the analysis. Heat recovery modifications would be an indirect cost and should not have been considered in the cost effectiveness calculation for MG-5. Regardless of the heat recovery costs, the cost-effectiveness is well within the range that the EPA considers reasonable and nothing in the TAR demonstrates to EPA that the cost-effectiveness is unreasonable.

Cost-effectiveness was not calculated in previous BACT determinations in which SCR was required on engines under the top-down BACT analysis because the companies did not argue that the technology should be rejected due to economic considerations. Once a control technology has been determined to be BACT on a particular type of source, i.e. an internal combustion engine, generally, that control technology should be considered economically feasible. Here, Cominco has not adequately demonstrated any site-specific factors to support their claim that the installation of this control technology is economically infeasible at the Red Dog Mine. Therefore, elimination of SCR as BACT based on cost-effectiveness grounds is not supported by the record and is clearly erroneous.

Furthermore, in order to justify economic infeasibility, the Region believes that the economic impact analysis conducted in the draft permit should have gone beyond a review of cost effectiveness to include an analysis of whether requiring Cominco to install and operate the more effective control strategies would have any adverse economic impacts upon Cominco specifically.

The cost effectiveness analysis in the Alternative Control Techniques document (EPA-453/R-93-032) is similar to the one performed by ADEC, finding a cost effectiveness of installing SCR resulting in a 90% NOx reduction on a 5-MW diesel-fired generator which operates approximately 8000 hours per year to be less than $1000 per ton of NOx removed (in 1993 dollars).

Water Injection

The Region is also concerned that the control cost analysis for direct water injection (DWI) was not performed properly by Cominco in its application. However, at this time, EPA does not believe that this deficiency is important since SCR has a higher control effectiveness than DWI. If EPA's determination that SCR is BACT is altered due to new information, EPA should require additional analysis of DWI.

Based on the analysis presented by ADEC, EPA finds no justification for Cominco's conclusion that the cost of SCR is unreasonable compared to the environmental and energy impacts associated with the use of this technology. EPA believes ADEC has made a convincing argument that SCR is technically feasible and cost effective and, therefore, should be BACT.

PSD Applicability to Units MG-1, MG-3 and MG-4

Cominco is requesting that the Wartsila generators (MG-1, MG-3, and MG-4) be placed under the operational cap that used to include MG-1, MG-3, MG-4, and MG-5. ADEC agreed and in removing MG-5 from the cap, required PSD review for only MG-5. Additionally, a seventh similar generator (MG-17) would be added. Thus, under the State's approach only MG-5 and MG-17 are being required by ADEC to install and operate the BACT. Cominco contends that MG-5 previously operated as a standby unit and that under the new configuration MG-1, MG-3, and MG-4 would not increase operation above the operational cap. In EPA's view, however, because the operational cap that used to apply to four units, would now apply to only three units under the cap. The cap is significantly higher than the past actual emissions from each generator. Thus, eliminating the operating limits results in a significant increase of potential emissions from MG-1, MG-3 and MG-4. Cominco should provide records documenting the prior operation of MG-1, MG-3, and MG-4 so that their past actual operation and emissions can be determined for comparison to the future potential emissions that could occur under the restructured cap. Cominco must show that a cap that formerly covered four generators would not allow additional operation of the three generators that remain under the cap.

While EPA policy would normally not require an emissions unit to be subjected to BACT due to an increase in utilization of existing capacity resulting from modifications elsewhere at the facility, it does require that all emission increases associated with the modifications be counted toward PSD applicability and included in the air quality analyses. In this case, however, full PSD review (including BACT) should apply to MG-1, MG-3, and MG-4 since it is determined that these generators will experience an increase in potential emissions as the result of a restructuring (and potential relaxation) of the operational cap specific to them.

PM-10 Increment Concerns for the Roadway

As reflected in the National Park Service's comments on the proposed permit, the control efficiency for particulate matter (PM) on the DeLong Mountain Transportation System (DMTS) that runs through Cape Krusenstern National Monument is over estimated. ADEC estimated a control efficiency of 89% while the NPS contends that 85% is too high for modeling input. In July of this year, Cominco monitors indicated an exceedence of the Class II PM_{10} 24-hour increment, further supporting the position that the PM controls are less efficient than anticipated. In fact, the Class II PM_{10} 24 hour increment in the National Monument will be violated if the control efficiency were assumed to be below 89%. Assuming the modeling results are acceptable (and assuming for the moment that the ambient air boundary will not change), the focus of our concerns are concentrated on the control of fugitive dust from the roads. The technical analysis document states:

> The current draft (8/31/99) permit has requirements for treatment of the road surface once a year with calcium chloride, weekly fugitive emissions surveys with additional road treatment if the duration of fugitive emissions is greater than two minutes, record keeping and reporting. Also, there is a requirement for operation of one ambient air monitor to "measure the effectiveness of the fugitive dust control and road surface treatment measures." The ambient air monitoring is required for the second and third calendar quarters for two years, but may be canceled after one year.

With the above control requirements, the Company claims credit for an 89% reduction in PM emissions from the roadway. The NPS and EPA think that 89% is too high. However, the modeling results indicate that 89% control is necessary for the project to comply with the PM10 increment; a lower percentage control would cause the modeling to predict exceedances of the PM10 increment. Therefore, ADEC should evaluate whether a reasonable increase in the control requirements (e.g., monthly application of calcium chloride during the four warmest and driest months of the year, more than one monitoring site, etc.) provide increased confidence that the road dust emissions are being treated in the best way reasonably possible (short of paving). Since the PM10 increment may be exceeded based on modeling results, additional verification monitoring should be required. Additionally, the NPS should be involved in the air quality monitoring program to insure that violations do not occur.

The modeling supplied by Cominco, and incorporated into the permit by ADEC, relies on the use of depletion to estimate ambient impacts in the ISCT3 model. As explained to ADEC by

EPA's modeling staff, the EPA has issued guidance that the use of deposition/depletion may be acceptable provided that the particle size data are determined to be adequate. In this instance, there are large uncertainties regarding particle size mass distribution and moisture content of the roadway emissions. There were apparently few samples taken, and the representativeness of the samples for use in the AP-42 emission methodology is disputable. While the particle size data was provided by Cominco, whether or not the data are adequate to justify the use of the deposition/depletion option of ISCT3 is unclear at this time. Based on the modeling deficiencies identified above, ADEC should provide additional documentation or conduct additional modeling analysis to demonstrate that he increment conclusions are technically sound and consistent with agency guidance.

Ambient Air

The ambient air boundary for the facility is not clearly and lawfully defined. The Public Access Control Plan, at Section 19, page 40 of the final draft permit, indicates that the boundaries are reflected in the Ambient Air Boundary Map. The map is not included with the permit or the TAR, nor does ADEC staff seem to know precisely where that boundary is. It does appear, however, that the facility boundary, i.e. the area which is excluded from meeting the ambient air quality requirements, is far larger than it needs to be for the safe and efficient operation of the mine. Due in part to the ambiguity and size of the ambient air boundary, there are related concerns with the modeling and increment consumption for PM and NOx.

There is considerable uncertainty about when and where the various ambient air boundary was established. In 1983, EPA reviewed the ambient air delineation at the mine and agreed with ADEC that "...all areas outside a circle around the mill the radius of which is defined by half the closest distance between the mill and the accommodations... Rough measurements show this radius to be approximately 800 feet. NAAQS and PSD increments apply to all areas outside this circle." March 25, 1983, letter from Michael Johnston, EPA. As recently as 1994, EPA believed that the 1983 EPA specified boundary was still in force, that the atmosphere external to Cominco worker housing was ambient air, and that it would be inappropriate to expand the boundary. In 1994, in light of measured exceedances of the NAAQS for lead in the early1990's by a monitor on top of the worker housing, discussions took place between ADEC, EPA, OSHA, and MSHA concerning ambient air at the Red Dog mine. Subsequent to those discussions, ADEC, apparently under the impression that the worker housing need not be considered ambient air and that the 1983 boundary no longer applied, agreed with Cominco to expand the ambient air boundary. EPA was not party to that agreement. In fact, it now appears that the boundary was first expanded in 1988 and then again in 1994 to more than double the size of the area that was considered not ambient air. Discussions with the ADEC indicate that a large eastward extension of the ambient air boundary is being added with this current proposed PSD permit action.

The general EPA policy states that "the exemption from compliance with ambient air is available only for the atmosphere over land owned or controlled by the source and to which public access is precluded by a fence or physical barrier." December 1980, letter from former

EPA Administrator Costle. Furthermore, "[A]mbient air is defined in terms of public access, not the frequency or likelihood of access, length of stay, age of the person or other limitations." May 16, 1985, Memo from Tikvart, EPA to EPA Regional Meteorologists. Thus, typical measures such as signs indicating "authorized personnel only" or 'no trespassing" would not constitute a physical barrier or adequately preclude access.

Based on the limited information regarding the delineation of the Red Dog mine ambient air boundary, the Public Control Access Plan appears insufficient to preclude public access by fence or other physical barrier. It is clear that although the modeling analyses treats the haul road as not ambient air, the public is allowed to cross it. The Public Access Control Plan acknowledges that there are other areas around the boundary where public access is possible. Furthermore, the warning signs to be posted at a few locations along the boundary warn only of generalized heavy industrial equipment and machinery-related hazards, but are wholly inadequate to inform the public (including off-duty employees) that the NAAQS may be exceeded beyond that point. Thus, even if the boundary is more clearly defined, additional information is required to determine whether public access to areas within the facility boundary is in fact "precluded by fence or other physical barrier."

Additional concerns relate to the haul road from the mine area to the port. ADEC stated in their Response to Comments to the NPS that "the road appears to be ambient air." The road is not controlled by Cominco; it is owned by the Alaska Industrial Development and Export Authority, a state agency, who has characterized the road as a "publically owned multi-use industrial roadway." While ADEC believes the road is ambient air, they allowed the Company, based on an agreement with the Company in their 1988 permit action, to not locate model receptors any closer than 91.4 meters (300 feet) to the centerline of the road. (Thus, the higher concentrations nearer to the road were not modeled.) This appears to be inconsistent with EPA ambient air policy.

Additionally, in this proposed permitting action, ADEC is allowing Cominco to substantially expand the boundary. The ADEC approach to ambient air in this case seems to be that as long as Cominco owns or leases (i.e. has authority to restrict access), and posts some signs forbidding unauthorized access along the boundary, the area within the boundary will not be considered ambient air. There does not appear to be any determination that the additional area is necessary for the safe and efficient operation of the mine or that public access is precluded. This approach is contrary to EPA policy. Considering the critical nature of the NO2 increment prediction (97.2% of the available increment is consumed by Cominco sources), it appears that if the ambient air boundary were not expanded as proposed by the State and Cominco, the model results would show violations of the PSD increment for NO2.

Since the 1983 EPA specified ambient air boundary is currently in force, the Company should provide four things before ADEC or EPA should consider an expansion of that boundary. The Company should provide a large detailed map and perhaps a legal description of the ambient air boundary they would propose. They should explain the rationale for needing to expand the boundary beyond that specified by EPA in 1983. They should continue to consider the air external to worker housing (and other areas accessible to off-duty workers) as ambient air. (In this regard, ADEC should consider imposing additional post-construction monitoring requirements for the worker housing area as a means to assure NAAQS compliance and identify the need for additional safeguards.) They should clearly demonstrate how they will preclude public access to non-ambient air areas in a manner consistent with EPA policy, i.e., by "a fence or other physical barrier."

Conclusion

For all the reasons stated above, the Region concludes that the permit limits for the Warsila engines for NOx emissions contained in the PSD permit are clearly erroneous and the BACT analysis for MG-1, MG-3, MG-4, MG-5 and MG-17 clearly indicates that selective catalytic reduction is the control technology of choice. MG-1, MG-3 and MG-4 are also subject to PSD and are subject to the BACT requirements. The BACT analyses are deficient in that they fail to reach conclusions that are supported by the PSD regulations, procedures or available information. Additional documentation is necessary to support the conclusion that PM-10 increment will not be violated on the road. The proposed permit does not clearly define the ambient air boundary, nor does it adequately preclude public access. As a result, Region 10 considers the proposed permit, if issued, to be in violation of the Clean Air Act and its implementing regulations.

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TABLE 5-11. DIESEL-FUELED SCR APPLICATIONS FOR ONE CATALYST VENDOR[57]

Installation date	Engine manufacturer	Engine model	Fuel	Power, hp	Speed, rpm	Load	Ammonia control	Performance test results		Catalyst changes and operating hours
								NO_x reduction, %	Ammonia slip, ppmv	
02/93	CATERPILLAR	3408	Diesel	475	1,800	Variable	Load following	90	5	None
01/91	CATERPILLAR	3412	Diesel	750	1,800	Variable	Load following	95	20	None, 4500 hrs
12/91	CUMMINS	KTA 19-G1	Diesel	560	1,800	Variable	Load following	90	20	None, 400 hrs
09/89	CATERPILLAR	3306	Diesel	270	2,100	Constant	Manual	90	30	None
01/90	COOPER	LSV16	Diesel	2,500	700	Variable	Load following	94	30	None, 12000 hrs
03/90	CATERPILLAR	3516 (3)	Diesel	2,850	1,800	Variable	Load following	95	20	None, 600 hrs
02/90	DETROIT	16V149 (2)	Diesel	2,350	1,800	Variable	Load following	88	30	None, 600 hrs

Table 4. Gas-Fired reciprocating Engines from RBLC 5/31/99

Small Natural Gas-Fired Engines				Issue/	Emission Rate				
			Rating	Start-Up	(g/BHP-Hr)		(g/kWh)		
Project Name	Permit #	Project Description	(HP)	Date	NOx	VOC	NOx	VOC	Control
Richmond Exploration	CA-0450	1 NG IC engines	200	10/24/91					NSCR
De La Guerra Power	CA-0416	1 NG generators	380	11/12/91					NSCR
Snyder Oil	WY-0020	1 NG compressors	520	8/29/94	2.00	0.50	2.7	0.7	NSCR
Snyder Oil	WY-0020	1 NG generators	385	8/29/94	2.00	0.50	2.7	0.7	NSCR
Snyder Oil	WY-0020	1 NG generators	577	8/29/94	2.00	0.50	2.7	0.7	NSCR
Western Envir Engr	CA-0642	2 engines	175	5/2/95					catalyst
Gilra Onions	CA-0645	6 rich-burn NG IC engines	130	6/18/95					catalyst
So Cal Gas	CA-0655	1 NG IC engines	132	6/30/95					catalyst
Bakersfield Cellular	CA-0682	1 NG generators	72	7/20/95					catalyst
City of Clovis	CA-0791	1 NG IC engines	300	11/8/96	0.33	0.07	0.4	0.1	catalyst
Toys R Us	CA-0792	1 NG IC engine		11/27/96	14.60				
Vintage Petroleum	CA-0788	13 engines	150	2/4/97					catalyst
Vastar Res	CO-0033	1 NG compressors	421	7/31/97	1.00	0.01			NSCR
Vastar Res	CO-0035	1 NG compressors	421	7/31/97	1.00	0.01			NSCR
Mobil	CA-0754	1 NG IC engines	280	8/28/97	1.50		2.0	0.0	clean burn
Phila SW Water Treat	PA-0096	2 NG IC engines	595		2.00				lean burn
Phila SW Water Treat	PA-0097	3 NG IC engines	595		2.00				lean burn

Large Natural Gas-Fired Engines				Issue/	Emission Rate				
			Rating	Start-Up	(g/BHP-Hr)		(g/kWh)		
Project Name	Permit #	Project Description	(HP)	Date	NOx	VOC	NOx	VOC	Control
Northern Nat Gas	IA-0023	1 NG compressors	4000	9/5/90	1.80		2.4	0.0	combustion
Northern Nat Gas	IA-0023	2 NG compressors	2000	9/5/90	1.80		2.4	0.0	combustion
FL Gas&Transmission	FL-0046	1 NG compressors	4000	5/8/91	2.00		2.7	0.0	combustion
FL Gas&Transmission	FL-0051	1 NG compressors	2400	6/10/91	2.00		2.7	0.0	combustion
FL Gas&Transmission	MS-0021	1 NG IC engines	2400	6/14/91	2.00	1.33	2.7	1.8	combustion
Swift Energy	OK-0026	7 NG IC engines	1132	8/5/91					catalyst
CGN Transmission	PA-0085	1 NG compressors	4200	9/24/91	2.00	0.90	2.7	1.2	clean burn
Pacific Energy	CA-0525		2860	2/25/92	0.80		1.1	0.0	lean burn
CGN Transmission	OH-0211	2 NG compressors	4200	3/11/92	2.00	0.90	2.7	1.2	combustion
CGN Transmission	OH-0211	1 NG compressors	4200	3/11/92	2.60	0.80	3.5	1.1	combustion
CGN Transmission	PA-0087	4 NG compressors	3200	3/13/92	2.00	0.80	2.7	1.1	lean burn
CGN Transmission	OH-0212	2 NG compressors	4200	4/8/92	2.00	0.98	2.7	1.3	combustion
CGN Transmission	OH-0213	1 NG compressors	4200	6/28/92	2.00	0.80	2.7	1.2	combustion
CGN Transmission	OH-0213	1 NG compressors	3200	6/28/92	2.00	0.80	2.7	1.1	combustion
Temple U	PA-0095	1 1.8 MW NG generator		10/2/92	2.00				lean burn
Snyder Oil	CO-0022	8 NG IC engines	2500	11/13/92	2.00				lean burn
Texaco	LA-0082	8 NG compressors	1642	2/1/93			0.0	0.0	
Marshal Municipal Util	MO-0003	1 NG IC engines	8500	4/6/93	2.00	0.7			clean burn
Marshal Municipal Util	MO-0019	6.3 MW NG generator		4/6/93	2.00	0.7			clean burn
CGN Transmission	WV-0011	1 NG compressors	6060	5/3/93	2.00	0.82	2.7	1.1	lean burn
North Star Recycle	OH-0220	3 NG IC engines	1700	6/8/93	1.95	0.4	2.6	0.5	catalyst
FL Gas&Transmission	FL-0075	1 NG compressors	4000	9/27/93	2.00		2.7	0.0	lean burn
Williams Field Ser.	NM-0021	1 NG compressors	1000	10/29/93	1.40	1	1.9	1.3	clean burn
Intel	AZ-0022	5 NG generators	2200	4/10/94					acid inject.
Indiana U of PA	PA-0122		8366	12/29/94	1.90		2.5	0.0	clean burn
Transcontinental	PA-0118	6 NG compressors	2050	6/5/95	4.00		5.4	0.0	LEC
Transcontinental	PA-0118	1 NG compressors	5500	6/5/95	4.00				LEC
Transcontinental	PA-0118	2 NG compressors	3400	6/5/95	4.00				LEC
Transcontinental	PA-0118	4 NG compressors	2100	6/5/95	7.00				LEC
Meridian Oil	NM-0025	8 NG compressors	2650	8/1/95	1.50	6.60	2.0	8.8	clean burn
Meridian Oil	NM-0028	4 NG compressors		10/27/95	0.70	0.8	0.9	1.1	clean burn
CGN Transmission	PA-0140	1 NG IC engines	1000	2/28/96	7.00	1.10	9.4	1.5	LE7
CGN Transmission	PA-0148	1 NG IC engines	2000	2/29/96	4.00	1.65	5.4	2.2	
CGN Transmission	PA-0146	1 NG IC engines	3400	2/29/96	4.00	0.83	5.4	1.1	LE4
City of Tulare	CA-0692			3/13/96	1.00		1.3	0.0	lean burn
Stocton	CA-0755	1 NG IC engines	2700	11/22/96	1.25	0.75	1.7	1.0	lean burn
Western Gas-Hilight	WY-0033	2 NG compressors	1500	3/31/97	2.00				catalyst
Williams Field Services	NM-0030	14 NG compressors	1478	6/3/97	1.50	1.00	2.0	1.3	
Vastar Res	CO-0026	1 NG compressors	1215	7/31/97	1.00	0.01			NSCR
Vastar Res	CO-0028	2 NG compressors		7/31/97	1.00	0.01			NSCR
Vastar Res	CO-0029	2 NG compressors		7/31/97	1.00	0.01			NSCR
Vastar Res	CO-0030	1 NG compressors	1215	7/31/97	1.00	0.01			NSCR
Vastar Res	CO-0030	2 NG compressors		7/31/97	1.00	0.01			NSCR
Vastar Res	CO-0032	1 NG compressors		7/31/97	1.00	0.01			NSCR
Vastar Res	CO-0032	1 NG compressors	739	7/31/97	1.00	0.01			NSCR
Vastar Res	CO-0032	1 NG compressors	1215	7/31/97	1.00	0.01			NSCR
Vastar Res	CO-0033	1 NG compressors	738	7/31/97	1.00	0.01			NSCR
Vastar Res	CO-0033	1 NG compressors	1215	7/31/97	1.00	0.12			NSCR
Vastar Res	CO-0034	2 NG compressors	1478	7/31/97	1.50	0.01			NSCR
Vastar Res	CO-0034	1 NG compressors	1216	7/31/97	1.00	0.01			NSCR
Vastar Res	CO-0035	1 NG compressors	1215	7/31/97	1.00	0.12			NSCR
Vastar Res	CO-0036	3 NG compressors	1215	7/31/97	1.00	0.12			NSCR
Monterey	CA-0789		1274	4/23/98	1.20		1.6	0.0	lean burn
Williams Field Ser.	NM-0040	6 NG compressors	4540	9/23/98	1.50	1	2.0	1.3	lean burn
Baba Petrol	CA-0852	1 NG IC engines	747	10/12/98	0.15				catalyst
CGN Transmission	PA-0145	1 NG compressors	3400		4.00	0.82	5.4	1.1	
Cominco--Red Dog	AK	6 diesel compressors	6000				11.0		
Western Envir Engr	CA-0642								

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Table 4. Oil-Fired reciprocating Engines from RBLC 5/31/99

Small Oil-Fired Engines				Issue/	Emission Rate				
			Rating	Start-Up	(g/BHP-Hr)		(g/kWh)		
Project Name	Permit #	Project Description	(HP)	Date	NOx	VOC	NOx	VOC	Control
Archie Crippen	CA-0830	1 IC diesel engine	500	12/9/97	6.20	0.3			
Cunningham Davis Enviro	CA-0693	1 IC diesel engine	173	4/6/96	10.40				combustion
Kearney Ventures Ltd	CA-0691	1 IC diesel engine	208	1/12/96	6.30	0.33			combustion
Parker Hannifin	CA-0717	1 IC diesel engine	450	1/11/96	9.50				combustion
Robison, Carlon & Carlon	CA-0586	1 IC diesel engine							
Tracey Material Recovery	CA-0758		360	10/29/96	9.60				combustion
Williams Bolthouse Farms	CA-0753	1 IC diesel engine	402	6/27/96	7.20				combustion

Large Oil-Fired Engines				Issue/	Emission Rate				
Project Name	Permit #	Project Description	(HP)	Date	NOx	VOC	NOx	VOC	Control
Phila NE Water Treatment	PA-0097	7 IC diesel engines	1635	10/15/92	2.00	0.32			SCR
Phila SW Water Treatment	PA-0096	11 IC diesel engines	1156	10/15/92	2.00	0.32			SCR
Resource Renewal Technologies	CA-0562	1 IC diesel engine	951	6/18/93	6.60	0.33			combustion

Table 4. Gas-Fired reciprocating Engines from RBLC 5/31/99

Small Natural Gas/Oil-Fired Engines				Issue/	Emission Rate				
			Rating	Start-Up	(g/BHP-Hr)		(g/kWh)		
Project Name	Permit #	Project Description	(HP)	Date	NOx	VOC	NOx	VOC	Control

Large Natural Gas/Oil-Fired Engines				Issue/	Emission Rate				
			Rating	Start-Up	(g/BHP-Hr)		(g/kWh)		
Project Name	Permit #	Project Description	(HP)	Date	NOx	VOC	NOx	VOC	Control
Indiana U of PA	PA-0122	4 gas/oil IC engines (gas)	8386	12/29/94	0.75				clean burn
Indiana U of PA	PA-0122	4 gas/oil IC engines (oil)	8366	12/29/94	1.90	0.75			clean burn

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no.	el. power kW	type of engine	fuel type	modul number	NOx - limit guaranteed mg/Nm3 5% O2	customer	type of use	filter	SCR	OXI	country	year of order	running hours per year
1	14'000	Wärtsilä Diesel	heavy fuel oil	400	500	Cerestar	heat power		X	X	D	1994	8'000
2	12'000	Pielstick	heavy fuel oil	360	300	Stadtwerke Västeras	heat power		X	X	S	1991	5'000
3	6'400	Wärtsilä Diesel	heavy fuel oil	210	1000	Chia Hsin	heat power		X		RC	1995	8'000
4	6'400	Wärtsilä Diesel	heavy fuel oil	210	1000	Chia Hsin	heat power		X		RC	1995	8'000
5	6'400	Wärtsilä Diesel	heavy fuel oil	210	1000	Chia Hsin	heat power		X		RC	1995	8'000
6	6'400	Wärtsilä Diesel	heavy fuel oil	210	1000	Chia Hsin	heat power		X		RC	1995	8'000
7	6'400	Wärtsilä Diesel	heavy fuel oil	210	1000	Lea Lea	heat power		X		RC	1995	8'000
8	6'400	Wärtsilä Diesel	heavy fuel oil	210	1000	Lea Lea	heat power		X		RC	1995	8'000
9	6'400	Wärtsilä Diesel	heavy fuel oil	210	1000	Lea Lea	heat power		X		RC	1995	8'000
10	6'400	Wärtsilä Diesel	heavy fuel oil	210	1000	Lea Lea	heat power		X		RC	1995	8'000
11	6'400	Wärtsilä Diesel	heavy fuel oil	210	1000	Lea Lea	heat power		X		RC	1996	8'000
12	6'400	Wärtsilä Diesel	heavy fuel oil	210	1000	Linköping	heat power		X		S	1996	8'000
13	5'710	Wärtsilä Diesel	heavy fuel oil	210	1000	Linköping	heat power		X		S	1996	8'000
14	5'710	Wärtsilä Diesel	heavy fuel oil	196	1000	TCCO	heat power		X		RC	1996	8'000
15	6'000	MTU	diesel	196	1000	TCCO	heat power		X		RC	1996	8'000
16	6'000	MTU	diesel	176	500	Allgäuer Überlandwerke	peak shaving	X	X	X	D	1992/96	500
17	6'000	MTU	diesel	176	500	Allgäuer Überlandwerke	peak shaving		X	X	D	1992	500
18	6'000	Pielstick/Deutz	diesel	176	500	Allgäuer Überlandwerke	peak shaving		X	X	D	1992	500
19	6'000	Pielstick/Deutz	diesel	176	1'000	WESAG Sermuth	peak shaving		X	X	D	1994	300
20	6'000	Pielstick/Deutz	diesel	176	1'000	WESAG Sermuth	peak shaving		X	X	D	1994	300
21	4'610	Sulzer	heavy fuel oil	176	1'000	WESAG Sermuth	peak shaving		X	X	D	1994	300
22	4'610	Sulzer	heavy fuel oil	162	760	Stena RoRo	marine ME		X	X	S	1997	5000
23	4'610	Sulzer	heavy fuel oil	162	760	Stena RoRo	marine ME		X	X	S	1997	5000
24	4'610	Sulzer	heavy fuel oil	162	760	Stena RoRo	marine ME		X	X	S	1997	5000
25	5'790	Wärtsilä Diesel	heavy fuel oil	162	760	Stena RoRo	marine ME		X	X	S	1997	5000
26	4'800	MBH	gas diesel	154	2'000	Italy gas	heat power		X		I	1995	6'000
27	4'890	MBH	gas diesel	143	1000	Magdeburg	heat power		X	X	D	1995	5'000
28	4'890	MBH	gas diesel	130	500	Hammelburg	heat power		X	X	D	1993	7'000

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no.	el. power kW	type of engine	fuel type	modul number	NOx - limit guaranteed mg/Nm3 5% O2	customer	type of use	filter	SCR	OXI	country	year of order	running hours per year
29	5'300	MBH	gas diesel	110	500	Doersheim	heat power		X	X	D	1997	6'000
30	3'680	Pielstick	heavy fuel oil	90	300	Swedish Navy "IB ATLE"	marine ME		X	X	S	1996	3'000
31	3'680	Pielstick	heavy fuel oil	90	300	Swedish Navy "IB ATLE"	marine ME		X	X	S	1996	3'000
32	3'680	Pielstick	heavy fuel oil	90	300	Swedish Navy "IB ATLE"	marine ME		X	X	S	1996	3'000
33	3'680	Pielstick	heavy fuel oil	90	300	Swedish Navy "IB ATLE"	marine ME		X	X	S	1996	3'000
34	3'680	Pielstick	heavy fuel oil	90	300	Swedish Navy "IB ATLE"	marine ME		X	X	S	1996	3'000
35	2'800	Sulzer	diesel	88	120	EW-Jona-Rapperswil	peak shaving		X	X	CH	1991	1'800
36	2'400	Pielstick	gas diesel	80	500	Stadtwerke Ülzen	heat power		X	X	D	1993	7'000
37	2'400	Pielstick	gas diesel	80	500	Stadtwerke Ülzen	heat power		X	X	D	1993	7'000
38	2'840	MAN	heavy fuel oil	80	500	MAN B&W diesel AG	research		X	X	D	1993	2'000
39	2'400	MWM	diesel	80	1'000	Uelzen 2	heat power		X	X	D	1993	500
40	2'700	Pielstick	diesel	77	1'000	Hannover Papier	heat power		X	X	D	1997	5'000
41	2'400	MBH	gas diesel	72	1'000	Halberstadt	heat power		X	X	D	1992	6'000
42	2'400	MBH	gas diesel	70	1'000	Magdeburg	heat power		X	X	D	1996	5'000
43	2'400	MBH	gas diesel	70	1'000	Magdeburg	heat power		X	X	D	1995	5'000
44	2'650	MBH	gas diesel	70	1'000	STW Halberstadt	heat power		X	X	D	1996	5'000
45	2'400	MBH	gas diesel	70	500	Halberstadt	heat power		X	X	D	1996	8'000
46	2'650	MBH	diesel	70	250	Harzgerode Metallwerke	heat power		X	X	D	1996	6'000
47	2'650	MBH	diesel	70	500	Mukran I	heat power		X	X	D	1998	6'000
48	2'650	MBH	diesel	70	500	Mukran II	heat power		X	X	D	1998	6'000
49	2'600	Nohab	diesel	64	400	Workboat	marine ME		X	X	USA	1998	2'500
50	2'600	Nohab	diesel	64	400	Workboat	marine ME		X	X	USA	1998	2'500
51	2'100	B+W	diesel	63	1'000	Piedersdorfer	mech.power		X	X	D	1995	4'000
52	1'800	Grandi Motori	gas diesel	56	50	Thermoselect Verbania	heat power		X	X	I	1995	6'000
53	2'500	Wärtsilä Diesel	diesel	56	500	Scandinavian Ferry Line	marine ME		X	X	S	1991	5'000
54	1'200	MWM	gas diesel	56	200	BTB, Steglitz, Berlin	heat power		X	X	D	1992	7'000
55	1'200	MWM	gas diesel	56	200	BTB, Steglitz, Berlin	heat power		X	X	D	1992	7'000
56	1'200	MWM	gas diesel	56	200	BTB, Steglitz, Berlin	heat power		X	X	D	1992	7'000
57	2'100	SKL	diesel	56	500	Stadtwerke Neumünster	heat power		X	X	D	1996	6'000
58	2'000	Sulzer	diesel	49	400	EW Schaffhausen	peak shaving		X	X	CH	1988	200

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no.	el. power kW	type of engine	fuel type	modul number	NOx - limit guaranteed mg/Nm3 5% O2	customer	type of use	filter	SCR	OXI	country	year of order	running hours per year
59	2'000	Sulzer	diesel	49	400	EW Schaffhausen	peak shaving		X	X	CH	1986	200
60	1'700	Sulzer	diesel	49	110	Sandoz Basel	peak shaving		X	X	CH	1989	300
61	1'500	New Sulzer	diesel	48	50	ETH Zürich	heat power		X	X	CH	1993	1'000
62	1'400	MWM	diesel	48	1'000	Uelzen 2	heat power		X	X	D	1993	500
63	1'620	MAN	gas diesel	48	500	Grimma	heat power		X	X	D	1994	8'000
64	1'620	MAN	gas diesel	48	500	Grimma	heat power		X	X	D	1994	8'000
65	1'620	MAN	gas diesel	48	500	Grimma	heat power		X	X	D	1994	8'000
66	1'800	MTU	diesel	48	500	Techn. Werke Friedrichshafen II	peak shaving		X	X	D	1994	500
67	1'800	MTU	diesel	48	500	Techn. Werke Friedrichshafen II	peak shaving		X	X	D	1994	500
68	1'500	Sulzer	diesel	42	110	Sandoz Basel	peak shaving		X	X	CH	1989	400
69	1'264	Caterpillar	diesel	42	400	Techn. Werke Friedrichshafen	peak shaving	X	X	X	D	1993	300
70	1'020	Caterpillar	diesel	42	500	Velten, Berlin	heat power	X	X	X	D	1994	2'000
71	1'020	Caterpillar	diesel	42	500	Velten, Berlin	heat power	X	X	X	D	1994	2'000
72	1'020	Caterpillar	diesel	42	500	Velten, Berlin	heat power	X	X	X	D	1994	2'000
73	1'620	Caterpillar	diesel	40	500	Tuttlingen	peak shaving	X	X	X	D	1997	600
74	1'723	2xSAAB1xHedem	diesel	36	300	National Maritime Administration	marine ME+AE		X	X	S	1994	5'000
75	1'300	Paxman	diesel	36	350	Royal Navy	marine AE		X	X	UK	1995	6'000
76	928	Sulzer	heavy fuel oil	36	700	Stena RoRo	marine AE		X	X	S	1997	4'000
77	928	Sulzer	heavy fuel oil	36	700	Stena RoRo	marine AE		X	X	S	1997	4'000
78	928	Sulzer	heavy fuel oil	36	700	Stena RoRo	marine AE		X	X	S	1997	4'000
79	1'200	Caterpillar	diesel	30	500	Energolux Astra Werk	peak shaving		X	X	L	1994	1'000
80	725	MTU	diesel	30	sootfilter	LIT Hamburg	peak shaving	X			D	1994	300
81	725	MTU	diesel	30	sootfilter	LIT Hamburg	peak shaving	X			D	1994	300
82	1'100	Wärtsilä Diesel	gas	30	120	KVA Weinfelden	heat power		X	X	CH	1995	5'000
83	1'700		diesel	30	400	Obergoms	heat power		X	X	CH	1997	500
84	900	MWM	diesel	25	1'000	EW Schwandorf	heat power		X	X	D	1994	2'500
85	900	MWM	diesel	25	1'000	EW Schwandorf	heat power		X	X	D	1994	2'500
86	1'000	MTU	diesel	25	500	EW Hindelang	heat power		X	X	D	1994	1'000
87	860	Mercedes	diesel	25	120	EW Jona-Rapperswil	peak shaving		X	X	CH	1994	500
88	860	Mercedes	diesel	25	120	EW Jona-Rapperswil	peak shaving		X	X	CH	1994	500

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no.	el. power KW	type of engine	fuel type	modul number	NOx - limit guaranteed mg/Nm3 5% O2	customer	type of use	filter	SCR	OXI	country	year of order	running hours per year
89	1'097	Perkins	diesel	25 / F30	1000	Bauer + Sohn Holdorf	heat power	X	X	X	D	1998	6'000
90	1'000	MTU	diesel	25	400	LUK Helmbrechts	peak shaving		X	X	D	1996	400
91	864	Deman	diesel	25	1000	Kollmeder Presswerk Ergolding	heat power	X	X	X	D	1996	6'000
92	626	Jenbacher	gas	20	50	ETH Hönggerberg	heat power		X	X	CH	1994	4'000
93	626	Jenbacher	gas	20	50	ETH Hönggerberg	heat power		X	X	CH	1994	4'000
94	626	Jenbacher	gas	20	50	SKA Uetlihof	heat power			X	CH	1995	4'000
95	800	Jenbacher	gas	20	100	Thermoselect Verbania	heat power		X	X	I	1994	4'000
96	800	Caterpillar	diesel	20	1'000	NAM Deutag	mobil power		X	X	NL	1994	2'000
97	800	Caterpillar	diesel	20	1'000	NAM Deutag	mobil power		X	X	NL	1994	2'000
98	800	Caterpillar	diesel	20	1'000	NAM Deutag	mobil power		X	X	NL	1994	2'000
99	800	Caterpillar	diesel	20	1'000	NAM Deutag	mobil power		X	X	NL	1994	2'000
100	800	Caterpillar	diesel	20	1'000	NAM Deutag	mobil power		X	X	NL	1994	2'000
101	830	MTU	diesel	20	500	Telekom Giessen	peak shaving		X	X	D	1994	300
102	825	MWM	diesel	20	1'000	Piedersdorfer	mech. power		X	X	D	1995	3'500
103	630	MWM	gas diesel	20	50	SBG Grünenhof	heat power		X	X	CH	1995	6'000
104	681	Jenbacher	landfil gas	16	130	Deponie Rautenweg Wien	heat power		X	X	A	1994	4'000
105	681	Jenbacher	landfil gas	16	130	Deponie Rautenweg Wien	heat power		X	X	A	1994	4'000
106	681	Jenbacher	landfil gas	16	130	Deponie Rautenweg Wien	heat power		X	X	A	1994	4'000
107	681	Jenbacher	landfil gas	16	130	Deponie Rautenweg Wien	heat power		X	X	A	1994	4'000
108	681	Jenbacher	landfil gas	16	130	Deponie Rautenweg Wien	heat power		X	X	A	1994	4'000
109	681	Jenbacher	landfil gas	16	130	Deponie Rautenweg Wien	heat power		X	X	A	1994	4'000
110	681	Jenbacher	landfil gas	16	130	Deponie Rautenweg Wien	heat power		X	X	A	1994	4'000
111	681	Jenbacher	landfil gas	16	130	Deponie Rautenweg Wien	heat power		X	X	A	1994	4'000
112	681	Jenbacher	landfil gas	16	130	Deponie Rautenweg Wien II	heat power		X	X	A	1996	4'000
113	681	Jenbacher	landfil gas	16	130	Deponie Rautenweg Wien II	heat power		X	X	A	1996	4'000
114	540	MTU	diesel	16	450	Leopoldina Spital	peak shaving		X	X	D	1994	500
115	540	MTU	diesel	16	450	Leopoldina Spital	peak shaving		X	X	D	1994	500
116	835	MTU	diesel	16	1'000	AEG Oldenburg	peak shaving		X	X	D	1995	130

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no.	el. power kW	type of engine	fuel type	modul number	NOx - limit guaranteed mg/Nm3 5% O2	customer	type of use	filter	SCR	OXI	country	year of order	running hours per year
117	700	gasotto	gas	16	50	SLM Winterthur SEC-Gebäude	heat power		X	X	CH	1996	4'500
118	800	Caterpillar	diesel	16	1'000	RWG Berlin	peak shaving		X	X	D	1996	3'500
119	760	MTU	diesel	16	1'000	Stadtwerke Bühl	peak shaving		X	X	D	1996	1'000
120	662	Wärtsilä Diesel	diesel	16	400	Swedish Navy "IB ATLE"	marine AE		X	X	S	1996	2'000
121	662	Wärtsilä Diesel	diesel	16	400	Swedish Navy "IB ATLE"	marine AE		X	X	S	1996	2'000
122	662	Wärtsilä Diesel	diesel	16	400	Swedish Navy "IB ATLE"	marine AE		X	X	S	1996	2'000
123	662	Wärtsilä Diesel	diesel	16	400	Swedish Navy "IB ATLE"	marine AE		X	X	S	1996	2'000
124	475	GM	diesel	16	250	TPG Geneva	heat power		X	X	CH	1997	6'000
125	690	MWM	diesel	16	250	Bernau	heat power	X	X	X	D	1997	6'000
126	630	MTU	diesel	16	300	Hospital Lohr	heat power	X	X	X	D	1997	6'000
127	490	Detroit Diesel	diesel	16	400	Hospital Baden	peak shaving		X	X	CH	1997	150
128	490	Detroit Diesel	diesel	16	400	Hospital Baden	peak shaving		X	X	CH	1997	150
129	690	Perkins	diesel	16	250	Fa. Pfeiffer	heat power		X	X	A	1997	4'000
130	550	Sulzer	diesel	12	400	EW Heiden	peak shaving		X	X	CH	1992	150
131	500	MWM	landfill gas	12	70	Dimag, Liestal	heat power		X	X	CH	1993	8'000
132	470	Caterpillar	diesel	12	250	Bad Doberan	heat power		X	X	D	1993	6'000
133	470	Caterpillar	diesel	12	250	Bad Doberan	heat power		X	X	D	1993	6'000
134	470	Caterpillar	diesel	12	250	Bad Doberan	heat power		X	X	D	1993	6'000
135	400	Caterpillar	diesel	12	1'000	Heizhaus Treffurt	heat power		X	X	D	1993	5'000
136	400	Caterpillar	diesel	12	1'000	Heizhaus Treffurt	heat power		X	X	D	1993	5'000
137	400	Caterpillar	diesel	12	1'000	Heizhaus Treffurt	heat power		X	X	D	1993	5'000
138	400	Caterpillar	diesel	12	1'000	Heizhaus Treffurt	heat power		X	X	D	1993	5'000
139	400	Caterpillar	diesel	12	1'000	Zeppelin Bünde	heat power		X	X	D	1993	3'000
140	400	Caterpillar	diesel	12	1'000	Zeppelin Bünde	heat power		X	X	D	1993	3'000
141	800	MTU	diesel	12	1'000	Energolux BG	peak shaving		X	X	L	1994	200
142	800	MTU	diesel	12	1'000	Energolux BG	peak shaving		X	X	L	1994	200
143	800	MTU	diesel	12	1'000	Energolux BG	peak shaving		X	X	L	1994	200
144	725	MTU	diesel	12	1'000	Energolux BG	peak shaving		X	X	L	1994	200
145	800	MTU	diesel	12	1'000	Energolux BG	peak shaving		X	X	L	1994	100

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no.	el. power kW	type of engine	fuel type	modul number	NOx - limit guaranteed mg/Nm3 5% O2	customer	type of use	filter	SCR	OXI	country	year of order	running hours per year
146	500	Cummins	diesel	12	400	OGO Oberaach	heat power		X	X	CH	1995	3'000
147	300	Deutz MWM	rapeseed oil ester	12	500	Bank 24	heat power	X	X	X	D	1996	2'500
148	300	Deutz MWM	rapeseed oil ester	12	500	Bank 24	heat power	X	X	X	D	1996	2'500
149	463	Caterpillar	diesel	12	120	SUVA Bellikon	heat power	X	X	X	CH	1996	5'000
150	350	MAN	diesel	9	800	Stadt Lehnin	heat power		X	X	D	1992	4'500
151	350	MAN	diesel	9	800	Stadt Lehnin	heat power		X	X	D	1992	4'500
152	350	MAN	diesel	9	800	Stadt Lehnin	heat power		X	X	D	1992	4'500
153	470	Herford	diesel	9	1000	Kaiser KG, Hochstadt	heat power		X	X	D	1993	4'000
154	470	Herford	diesel	9	1000	Kaiser KG, Hochstadt	heat power		X	X	D	1993	4'000
155	330	Herford	diesel	9	1000	Kaiser KG, Hochstadt	heat power		X	X	D	1993	4'000
156	427	MWM	diesel	9	1'000	Hammelburg II	peak shaving		X	X	D	1994	200
157	416	Mercedes	diesel	9	1'000	Baatz Mercedes	heat power		X	X	L	1995	2'500
158	300	Caterpillar	diesel	9	1'000	Baatz Caterpillar	heat power		X	X	L	1995	2'500
159	353	Wärtsilä Diesel	diesel	9	400	Swedish Navy "IB ATLE"	marine AE		X	X	S	1996	2'000
160	509	MTU	diesel	8	1'000	Cargocenter	peak shaving		X	X	L	1995	500
161	400	MAN	diesel	8	1'000	Polyma	mobil power		X	X	D	1993	500
162	400	MAN	diesel	8	1'000	Polyma	mobil power		X	X	D	1993	500
163	400	MAN	diesel	8	1'000	Energolux KBL	peak shaving		X	X	L	1993	500
164	400	MAN	diesel	8	1'000	Polyma	mobil power		X	X	D	1993	500
165	350	MAN	diesel	8	500	Astra Satellite EWL	peak shaving		X	X	L	1993	200
166	350	MAN	diesel	8	500	Astra Satellite EWL	peak shaving		X	X	L	1993	200
167	434	MAN	diesel	8	500	Hasslacher Linz	heat power		X	X	A	1994	3'000
168	300	MAN	diesel	8	400	Davos NAD	heat power		X	X	CH	1994	2'000
169	280	MAN	diesel	8	500	Banzkow	peak shaving		X	X	D	1994	1'000
170	440	MAN	diesel	8	1'000	Polyma	mobil power		X	X	D	1994	500
171	350	Volvo	diesel	8	1'000	Kuelbacher	peak shaving		X	X	L	1994	300
172	443	MAN	diesel	8	500	Energolux	peak shaving		X	X	L	1994	200
173	270	MAN	gas	8	80	Wärmeverbund Samen	heat power		X	X	CH	1995	5'000

Reference list January 1998 combustion engines

HUG ENGINEERING

no.	el. power kW	type of engine	fuel type	modul number	NOx - limit guaranteed mg/Nm3 5% O2	customer	type of use	filter	SCR	OXI	country	year of order	running hours per year
174	270	MAN	gas	8	80	Wärmeverbund Sarnen	heat power		X	X	CH	1995	6'000
175	320	MAN	diesel	6	200	Alsa, Steinau	heat power		X	X	D	1991	2'500
176	320	MAN	diesel	6	200	Alsa, Steinau	heat power		X	X	D	1991	2'500
177	250	Caterpillar	diesel	6	500	Zeppelin Metallwerke	peak shaving		X	X	D	1992	1'000
178	140	Cummins	diesel	6	sootfilter	Hospital Hecheshorn	heat power	X			D	1997	8'000
179	140	Cummins	diesel	6	sootfilter	Hospital Hecheshorn	heat power	X			D	1997	8'000
180	140	Cummins	diesel	6	sootfilter	Hospital Hecheshorn	heat power	X			D	1997	8'000
181	140	Cummins	diesel	6	sootfilter	Hospital Hecheshorn	heat power	X			D	1997	8'000
182	250	MAN	diesel	4	1'000	Energolux MAN UBS	peak shaving		X	X	L	1993	200
183	227	Volvo	diesel	4	1'000	Energolux Schmit	peak shaving		X	X	L	1993	500
184	150	MAN	diesel	4	1'000	OML Leipzig	heat power		X	X	D	1994	5'000
185	200	Caterpillar	diesel	4	1'000	Cactus Mersch	heat power		X	X	L	1995	2'000
186	70	Cummins	diesel	2	100	Aerni, Arisdorf	heat power	X	X	X	CH	1991	1'000
187	60	Elsbett	vegetable oil	2	500	Evang. Akademie Sachsen	heat power		X	X	D	1994	6'000
188	120	SCANIA	diesel	2	1'000	Michalke	peak shaving		X	X	D	1994	300

Summary

total installed mech. power output of engines	344'780	kW
total module number	10055	-
total running hours per year	569'680	h
total mass of reduced NOx per year	17992	tons